PRELIMINARY PROPOSAL FOR FY2005 FUNDING

Title: Population dynamics of Pacific lampreys: stock-recruitment relations, population bottlenecks, and compensatory mechanisms.

Study code: ADS-P-00-8

This proposal addresses Objective 10 under the study code identified in the one-page AFEP research summary entitled "Development of alternative means to pass adult Pacific Lamprey around dams".

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PROJECT SUMMARY

RESEARCH GOAL

The goal of this study is to develop a life stage structured population model for Pacific lampreys to examine how the vital rates (i.e. reproduction, growth, metamorphosis, and mortality) influence their abundance and population dynamics. We will also examine whether compensatory mechanisms may be regulating the population size of Pacific lampreys and provide options for managers charged with trying to recover lamprey stocks.

This research will collate all relevant data on Pacific lamprey populations (e.g., population sizes, fecundity, sex ratios, larval abundances, size at age, etc.) to construct stock-recruitment relations, explore the possibility of compensatory mechanisms occurring in lamprey populations, and develop a population dynamics model specific to Pacific lampreys. The model will be used to identify potential bottlenecks to lamprey population growth and should be considered fundamental and critical to evaluating options for the management and recovery of this valuable ecological resource.

STUDY OBJECTIVES

1. Conduct a thorough literature review and survey of regional lamprey researchers to collect data for parameterization of the population model and to identify specific data needs.

2. Develop life-stage structured population models for Pacific lamprey populations in selected streams.

3. Construct stream-specific stock-recruitment relations for lamprey, determine whether compensatory mechanisms may be operating in lamprey populations, and explore the influence of vital rates on lamprey demographics (AFEP research summary ADS-P-00-8 Objective 10).

RELEVANCE TO BIOLOGICAL OPINION

Pacific lampreys have been petitioned for listing under the Endangered Species Act. As outlined in the next section, Pacific lamprey populations have been reduced to a level where the potential listing under the Endangered Species Act is a common topic amongst the responsible federal agencies. Petitions to list 4 species of lampreys in the western U. S. have been filed.

PROJECT DESCRIPTION

BACKGROUND AND JUSTIFICATION

Pacific lampreys in the Columbia River Basin (CRB) have declined to only a remnant of their pre-1940's populations (Close et al. 1995). The ecological, economic, and cultural significance of this species is underestimated by most (Kan 1975; Close et al. 1995) and actions are currently being considered for their recovery in the CRB (Close et al. 1995). Identifying the biological and ecological factors that may limit lamprey production in the CRB is critical for their recovery. However, simply identifying these factors may not be enough—we need to know at what stage of the life cycle (i.e., larval, macropthalmia, adult) and at what locations limiting factors are exerting the greatest influence. Such knowledge would help identify bottlenecks to population growth in Pacific lampreys. For example, which has the greatest influence on limiting population growth of lampreys—effects on upstream migrating adults (i.e., human harvest and the "harvest" of individuals at man-made structures, such as dams) or on downstream migrating juveniles? Answers to questions like this would help managers focus research and recovery efforts where they would have the most benefit.

Population models are useful tools for studying the life cycle and demography of organisms and for exploring alternative hypotheses and management scenarios prior to implementation of a particular action. Such exploratory analyses can help managers focus on options for managing populations that would have the greatest potential biological benefit and be most cost-effective. Despite its potential benefit, a population model does not currently exist for Pacific lampreys; nor do we have information on stock-recruitment relations or compensatory mechanisms that may be operating in Pacific lamprey populations. As stated by Jones et al. (2003), compensatory mechanisms are demographic processes in animal populations that tend to regulate the abundance of those populations. Specifically, compensatory mechanisms work by increasing birth rates or decreasing death rates when population density decreases. In lampreys, examples of compensatory mechanisms include changes in: (1) sex ratios, (2) larval growth rates; and (3) age at metamorphosis (see Jones et al. 2003 for a detailed discussion).

Although research has been done evaluating potential biological and ecological factors limiting lamprey production in the CRB, almost nothing is known about lamprey population dynamics and the relative importance of limiting factors at different life stages. Proper management of a species requires knowledge of their life cycle and demography. Development and use of a population model for lampreys would: (1) identify factors limiting population growth [i.e., population bottlenecks]; (2) provide an understanding of the mechanisms limiting production at different life stages; and (3) be useful for exploring options for management and recovery of lampreys in the Pacific Northwest.

Population models have been useful in identifying population "bottlenecks" of other lamprey species. To help evaluate sea lamprey (*Petromyzon marinus*) control options in the Great Lakes for example, age-specific population models were used to examine uncertainty in stock-recruitment relations and compensatory mechanisms in sea lampreys (Haeseker et al. 2003; Jones et al. 2003).

From a conservation perspective, quantifying certain aspects of population dynamics is probably most important when a population has been reduced to small fraction of its original size (Hutchings 1999). Because of their declining populations and our limited biological knowledge, lamprey populations in the western U. S. are probably destined for listing under the federal ESA. Thus, it seems prudent to embark on the research described herein because it has the opportunity to provide critical information to managers charged with the protection and recovery of these fish.

PROJECT OVERVIEW

This will be a new research project using methods similar to work done on populations of sea lampreys (Haeseker et al. 2003). Although the objectives of lamprey researchers and managers in the Great Lakes are different from those of scientists in the western U. S. (i.e., controlling versus recovering lamprey populations), the basis for using population models and demographic information would be similar. In both cases, the use of population models would help researchers understand the dynamics of lamprey populations, what factors may be most important in limiting production, and what life stages may be most vulnerable to perturbations. In the Great Lakes, managers are concerned with controlling lamprey populations and thus can use information from modeling exercises to help them focus control options. For lamprey populations in the western U. S., knowledge of their population dynamics, stock-recruitment relations, and compensatory mechanisms would provide unprecedented detail into the potential mechanisms of their decline and help identify the best options for their recovery. This type of thinking, and its associated research and modeling efforts, have been key factors working towards recovery of collapsed stocks of Atlantic cod (*Gadus morhua*; Hutchings 1999; Fu et al. 2001), salmon, (Jager et al. 1997; Kareiva et al. 2000), and other fishes.

CURRENT STATUS

This will be a new project.

OBJEECTIVES AND METHODOLOGY

Objective 1.

Rationale

All relevant fisheries literature, both peer-reviewed and gray literature, will be searched for information on population modeling of lampreys. We will place particular emphasis on research conducted in the Great Lakes, Europe, and Japan because a significant amount of lamprey research has been conducted in these regions. Articles, reports, and other data will be collated and reviewed for information that could be useful for developing a model for Pacific lamprey populations. In addition, we will also contact all known lamprey researchers and managers in the Pacific Northwest and request information on lamprey populations. Completion

of this objective will reveal what data currently exists that may be useful for developing population models for Pacific lampreys, and will also indicate relevant data needs. Information from this Objective is necessary to complete Objective 2.

Schedule: October 2004 – September 2005.

Objective 2. Develop life-stage structured population models for Pacific lamprey populations in selected streams.

Rationale

Models have been used in the Great Lakes for many years to guide integrated sea lamprey management. For this objective, we will use and modify existing age-structured population dynamics models for sea lampreys as a template for modeling Pacific lamprey populations (Haeseker et al. 2003; Jones et al. 2003). A model will be constructed to describe the full life cycle of the Pacific lamprey, from age-0 recruitment through spawning. If sufficient data are available, separate models will be constructed for different streams because potential bottlenecks may occur in one stream (e.g., habitat limitations) but not in another. Some examples of data needs for the models would include spawner abundance, larval length-composition, length-age conversion, macropthalmia abundance, sex ratios, and age-at-metamorphosis. Information from this Objective is necessary to complete Objective 3.

Schedule: January – September 2005.

Objective 3. Determine whether compensatory mechanisms may be operating in lamprey populations, and explore the influence of vital rates on lamprey demographics (AFEP research summary ADS-P-00-8 Objective 10).

Rationale

Information on spawning Pacific lamprey abundance and larval recruitment at age 1 will be used to estimate the parameters of a Ricker stock-recruitment relation

$$R = \alpha S e^{-\beta S}$$

where R is recruitment, S is the spawning female Pacific lamprey abundance, and α and β are estimated parameters. These relations will be used to test for the presence of compensation (density-dependent survival) between spawning and age 1 (Jones et al. 2003). Data collated from Objective 1 will be used to determine population abundances, sex ratios of fish in different streams, larval densities and growth rates, age at metamorphosis, and to further explore compensatory mechanisms in lamprey populations. The model, or models, developed in Objective 2 will be used to explore how variation in vital rates influences lamprey abundance and demography. Sensitivity analyses will be done on models to determine which parameters and/or life stages produce the greatest change in population growth rates.

Schedule: June – September 2005.

FACILITIES AND EQUIPMENT

We anticipate that all of the work for this project will be conducted at the Columbia River Research Laboratory (USGS) and the Columbia River Fisheries Program Office (USFWS). All offices are well supplied with modern equipment, computers, and analysis software necessary to complete this research. The combined efforts of the USGS and the USFWS results in much of the expertise, equipment, and technology necessary to complete this research, which we believe will result in substantially lower costs and increased efficiency.

IMPACTS

We anticipate that any impacts from this study on other ongoing or proposed research will be negligible. We are unaware of any significant biological impacts from this study.

COLLABORATIVE ARRANGEMENTS AND SUBCONTRACTORS

This research should be relevant to most lamprey research in the Columbia River Basin. We believe that development of population models for Pacific lampreys will be critical for understanding their biology and guiding future research. We are aware of most efforts ongoing in the Basin, and it is possible that data for this research could come from many sources. We will cooperate to the fullest extent to maximize data collection and collation activities. We may use contract labor for some activities.

List of Key Personnel and project duties

Matthew G. Mesa, Principal Investigator

James H. Petersen, Principal Investigator

Steve Haeseker, Principal Investigator

TECHNOLOGY TRANSFER

Results from this study will be disseminated in the form of annual reports of research, oral presentations and briefings, and peer-reviewed journal publications. We will produce a draft report of preliminary findings in the fall of 2005, anticipating that further work will be conducted in FY 2006.

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